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# BULLETIN

OF THE

# TORREY BOTANICAL CLUB

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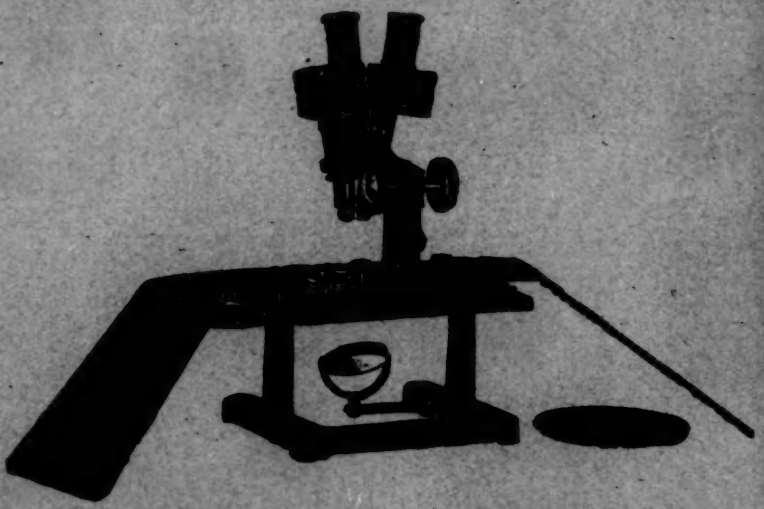

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Vol. 46 No. 7

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JULY, 1919

# Taxonomic studies in Vernonia and related genera

HENRY ALLAN GLEASON

In preparing the manuscript for the tribe Vernonieae, to be published in the North American Flora, several new species and varieties were recognized and a few nomenclatorial changes became necessary. One of the latter involves the erection of a new genus. Since the form of the North American Flora demands relatively concise descriptions and permits no critical discussion, the present paper is issued in advance.

A variety, in the opinion of the writer, represents a group which is not worthy of specific rank, yet demands recognition in the intensive study of a species. In general, varieties are not admitted into the North American Flora. Specific descriptions are drawn broadly enough to include all the varieties, while the varietal names are cited among the synonyms. The same treatment will be used for the varieties published here.

Although this paper and the manuscript for the North American Flora have been prepared at the New York Botanical Garden and are based primarily on the collections there, the writer has been greatly assisted by material from many American herbaria and takes this opportunity of expressing his thanks: to Mr. C. C. Deam and Mr. J. Lunell for material from their private herbaria; to those in authority at the University of California, the Field Columbian Museum, the University of Illinois, the Iowa Agricultural College, the University of Kentucky, the University of

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Minnesota, the Ohio State University, and the University of Wisconsin for the loan of material; to the directors or curators of the Brooklyn Botanic Garden, the Gray Herbarium, the National Herbarium, the New England Botanical Club, and the Philadelphia Academy of Sciences for the facilities of their herbaria and libraries; to Dr. B. L. Robinson, Dr. J. M. Greenman, Mr. W. R. Maxon, and Mr. E. E. Watson for information, assistance, and criticism; and especially to the University of Michigan, where part of the work was done.

### VERNONIA BORINQUENSIS Urban

In describing the species, Urban took as the type a form with hirsute achenes, resinous-dotted leaves, and short straight appressed hairs on the lower leaf surface. This is the commonest form in American herbaria. Urban's variety *Stahlii* covers a much rarer form with glabrous achenes and without resinous dots on the leaves. Two other forms also occur, which are deserving of varietal names.

**Vernonia borinquensis resinosa** var. nov.

Achenes glabrous; leaves conspicuously dotted with glands and resin on the lower surface: otherwise like the typical form of the species.

TYPE: *ex herb. E. W. D. Holway*, collected at Cayey, Porto Rico, January, 1911, and deposited in the herbarium of the New York Botanical Garden.

**Vernonia borinquensis hirsuta** var. nov.

Achenes hirsute; leaves densely sericeous-hirsute beneath with bent or curved hairs 2–4 mm. long, nearly or completely concealing the resinous dots; otherwise like the typical form of the species.

TYPE: *Britton, Stevens, & Hess 2471*, collected in a wooded valley, Rio de Maricao, Porto Rico, at an altitude of 500–600 meters, April 2, 1913, and deposited in the herbarium of the New York Botanical Garden. Field notes indicate that it is a vine, two meters long.

The species and its three varieties may be distinguished as follows:

| | |
|---|---|
| Achenes hirsute; leaves with resinous dots or glandular pits on the lower surface. | |
| Pubescence of short, straight, appressed hairs seldom exceeding 0.5 mm. in length. | *V. borinquensis.* |
| Pubescence on the lower leaf-surface of bent or curved hairs 2–4 mm. long. | *V. borinquensis hirsuta.* |
| Achenes glabrous. | |
| Glands on the lower leaf-surface present. | *V. borinquensis resinosa.* |
| Glands on the lower leaf-surface none. | *V. borinquensis Stahlii* |

### VERNONIA SERICEA L. C. Rich.

*Vernonia phyllostachya* (Cass.) Gleason.

We are indebted to Ekman for the application of the correct name to this well-known species. Specimens in American herbaria show a great variation in the size, proportion, and density of pubescence of the leaves, without offering legitimate opportunity for the separation of varieties.

### VERNONIA GNAPHALIIFOLIA Rich.

Until the last decade this species was poorly represented in American herbaria. The collections of the New York Botanical Garden now include an ample series of specimens, sufficient to give some idea of the range of variation within the species. On casual inspection, the specimens fall into two groups, characterized by wide and narrow leaves. The latter come from the provinces of Santa Clara, Camaguey, and Oriente, that is, from eastern Cuba; while the former are from Santa Clara, Havana, and Matanzas. The wide-leaved forms have leaves from $9 \times 19$ mm. to $21 \times 51$ mm., and the ratio of length to width varies from 2.1 to 3.4. The leaves of the narrow-leaved specimens range in size from $4 \times 23$ mm. to $14 \times 61$ mm., and their ratio from 3.2 to 5.7. They make accordingly a continuous series. In all cases the leaves are somewhat revolute and densely sericeous beneath. All specimens agree in the characters of inflorescence and flower-structure except one, *Shafer 2958*, from Holguin, Oriente, which lacks the resinous dots on the principal involucral scales.

Another specimen differs so much from the specific type that it may be described as a new variety.

**Vernonia gnaphaliifolia platyphylla** var. nov.

Leaf-blades broadly elliptic-ovate, less than twice as long as wide, flat, not revolute at the margin, closely and finely gray-tomentose beneath; otherwise resembling the typical form of the species.

TYPE: *Britton, Cowell, and Shafer 12,933*, collected at Ensenada de Mora, Oriente, March 26–29, 1912, and deposited in the herbarium of the New York Botanical Garden. It is described as a shrub, one meter high, and is the only broad-leaved representative of the species so far known from eastern Cuba. It is also the only specimen examined within the species without the revolute leaf-margin and with distinctly tomentose pubescence.

VERNONIA ICOSANTHA DC.

Ekman has pointed out the peculiar nomenclatorial confusion attached to this well-known species of the Lesser Antilles, and has chosen to apply to it the name *Vernonia arborescens* (L.) Sw. In describing *Conyza arborescens*, Linnaeus had before him not only the plate of Plumier, portraying the *Vernonia* of the Lesser Antilles, but also an actual specimen of a different species from Jamaica. A comparison of his text with the plate shows that the description could not have been taken from the plate alone, but was based primarily on the specimen. The latter accordingly becomes the type of the species and retains the specific name *arborescens*, and *V. icosantha* remains the first valid name for the species of Martinique and Guadeloupe.

**Vernonia Shaferi** sp. nov.

Stem shrubby, 1–2 m. high, the young branches closely cinereous-pubescent, becoming glabrate the second year; leaf-blades ovate-lanceolate or elliptic, the largest 4 × 12 cm., the upper much smaller, all acuminate, entire, acute at the base, dark green, minutely papillose-pubescent, and very sparsely resinous-dotted above, paler green but otherwise the same below; heads about eighteen-flowered, crowded in leafy secund cymes at the ends of the branches of the season; bracteal leaves oblong or oblong-ovate, acute, 5–10 mm. long; involucres broadly turbinate to campanulate, 6 mm. high, the scales rather closely imbricate, erect or appressed, narrowly oblong-lanceolate, acuminate, irregularly pubescent and ciliate, and usually resinous toward the

tip; achenes hirsute; pappus white, its bristles 6.5–7 mm. long, the paleae very irregular in length, as much as 1.5–2 mm. long, minutely erect-ciliate; flowers white or pink.

TYPE: *Shafer 172*, collected in Montserrat, January 23, 1907, and deposited in the herbarium of the New York Botanical Garden. The same herbarium also contains sheets of three other collections made on the same expedition, *Shafer 589*, *659*, and *661*.

This handsome species is obviously closely related to *V. longifolia* Pers., as shown by the shape and pubescence of the leaves, the inflorescence, and the character of the involucral scales. It is distinguished from that species at sight by the white pappus, as well as by the slightly larger heads, the much larger pappus-bristles, which are only 4–5 mm. long in *V. longifolia*, and the unusually long, barely ciliate paleae. It is a pleasure to name the species in honor of its first collector, the late John A. Shafer, who discovered several other interesting *Vernoniae* in the West Indies.

### VERNONIA RACEMOSA Delp.

*Vernonia racemosa* Delp. Mem. Accad. Torino II. **14**: 396. 1854.

*Vernonia araripensis* Gleason (in part), Bull. N. Y. Bot. Gard. **4**: 181. 1906, not Gardn.

*Vernonia sericea* L. C. Rich. subsp. *racemosa* Ekman, Ark. Bot. **13**[16]: 85. 1914.

The two sheets in the herbarium of the New York Botanical Garden, which were referred by Ekman to *V. racemosa* as a subspecies of *V. sericea*, differ in certain features from *V. sericea*, with which they are not associated geographically, and agree better in general character with the linear-leaved species of Hispaniola and adjacent Cuba. The species-group *Arborescentes*, which includes *V. sericea*, has leaves of a broad type, not revolute, and comparatively few spreading cymes near the ends of the branches, producing a rather short and broad inflorescence. *V. racemosa* and its allied species have revolute, linear leaves and narrow, elongate inflorescences, composed of relatively short and few-headed cymes distributed over a considerable length of the axis. While this latter character is largely one of habit, the narrow revolute leaves afford a ready and accurate means of distinguishing it and its allies from the *Arborescentes*.

### VERNONIA RIGIDA Sw.

Collected originally by Swartz in Jamaica in the middle of the eighteenth century, this excellent species has since been practically lost. Few botanists have examined Swartz's originals and as a result the name *V. rigida* has been applied by various collectors and students to several entirely different species. The genuine *V. rigida* was finally rediscovered by Wm. Harris at Upper Clarendon, Jamaica, December 27, 1917, and good specimens are now deposited in the herbaria of the Field Columbian Museum and the New York Botanical Garden. The species is obviously allied with the well-known Jamaican *V. acuminata* Less.

**Vernonia Sagraeana angusticeps** (Ekman) var. nov.

*Vernonia angusticeps* Ekman, Ark. Bot. **13**[15]: 14. 1914.

The sheet of *Wright 284*, on which the species of Ekman was based, in the Gray Herbarium agrees with the species in every particular except the small number (twelve) of flowers in the head and the consequently more nearly cylindrical involucre.

### SPECIES-GROUP BUXIFOLIAE

In the mountains of Haiti and Santo Domingo occurs a group of three poorly known species of *Vernonia*. Only eight specimens have been examined in American herbaria by the writer, while Ekman mentions twelve in various European collections. One of these, the last to be described, is *V. Tuerckheimii* Urban, which seems to a well-marked and easily recognized species. Another is a form with small leaves, averaging only 7 × 12 mm., and a short, cylindrical or ellipsoid involucre 3–4 mm. in diameter, or spreading under pressure to 5 mm. For convenience this will be designated here as species A. The third, here referred to as species B, has leaves averaging 10 × 23 mm., and a turbinate or almost salviform involucre, spreading at its mouth to a width of 7–9 mm. even when not pressed. While the involucre of species A offers no noteworthy feature, that of species B is remarkable for its imbrication. It is composed of five vertical but gently spiral rows of scales, with ten to thirteen scales in each row, beautifully imbricated, and with the outer ones gradually reduced at the acuminate base of the head. Ekman had before him apparently

only species A; at least he cites two collections which cover that species in the New York collection and fails to mention the peculiar involucre of species B, which is utterly unlike that of any other North American species. This species A is designated by him *V. buxifolia* (Cass.) Less., although he has not seen Cassini's type, and as a synonym he adds *V. domingensis* (Spreng.) DC., the type of which he has seen. These two names have been regarded as synonymous for over eighty years. The writer, in 1906, considered that species B was the true *V. buxifolia*, and described species A as new under the name *V. montana*. From this description and the cited specimen Ekman recognized that *V. montana* was co-specific with the plants which he had examined, and reduced *V. montana* to synonymy. At the same time he was unable to match Gleason's description of *V. buxifolia* (species B) with anything he had seen in European collections and decided that it was probably a new species. When he examined the New York material of these in 1914 he annotated the sheets of species A as genuine *V. buxifolia* and those of species B as "*V. buxifolia* forma."

Cassini described the involucre of *Lepidaploa buxifolia* as turbinate and regularly imbricated, with an assemblage of short rounded scales covering the summit of the peduncle at the base of the head. In this feature it can agree only with species B. De Candolle, in examining the type of Sprengel's *Proustia domingensis*, used terms which certainly apply to species B, but which do not emphasize the peculiar involucre. One can scarcely imagine that he would have passed by such a striking feature if the specimen had exhibited it. The writer is therefore convinced of the justice of maintaining *V. buxifolia* for species B, as he did in his revision in 1906. For species A, he must be guided by the negative evidence of De Candolle and the positive statement of Ekman in regard to *V. domingensis*, use that name for species A, and relegate his own *V. montana* to synonymy.

**Vernonia morelana** sp. nov.

A shrub 3–5 m. high, branching above; stems striate, closely gray-tomentose, becoming glabrate with age; leaf-blade firm, dull-green, ovate-oblong, 3 × 7.5 cm., on tomentose petioles 8mm.

long, entire or with a few low teeth, obtuse or rounded at the base and apex, closely scabrous-pubescent above, finely gray-tomentose beneath; upper and rameal leaves similar but smaller and more densely tomentose, those in the cymes broadly ovate to subrotund, 5–15 mm. long; cymes freely branching, forming a hemispheric cluster 2 dm. wide at the end of the branches; heads 21-flowered; involucre campanulate, 4–4.5 mm. high, its scales regularly imbricate, all appressed or barely spreading at the tip, outer and middle scales ovate to ovate-oblong, sharply acute or cuspidate, tomentose-ciliate and often puberulent on the back, inner scales lanceolate, sharply acute or subacuminate, 4 mm. long, nearly or quite glabrous; achenes thinly pubescent and densely resinous-glandular; pappus white or very pale tawny, the bristles 6 mm. long, the paleae narrow, 0.6–0.8 mm. long.

TYPE: *Pringle 7697*, collected by streams, Cuernavaca, Morelos, Mexico, altitude 5,000 feet, March 16, 1899, and deposited in the herbarium of the New York Botanical Garden.

While this species clearly resembles the other members of the species-group *Deppeanae* in leaf-habit, inflorescence, and pubescence, it is distinct in its glandular achene, a structure not observed elsewhere in the group. It resembles *V. canescens* H.B.K. in its white pappus, but differs in its pubescence and broader involucral scales. It approaches *V. Deppeana* Less. in its leaf-pubescence, but differs in its white pappus, sharper scales, larger involucre, and broader paleae. It is even more widely separated from the other species of the group.

**Vernonia salamana** sp. nov.

A shrub, 2–2.5 m. high, branching above; stem striate, thinly cinereous-pubescent or becoming glabrate; leaves thin but firm, pale olivaceous, the blades ovate-elliptic, 3 × 7 cm., undulate, entire or remotely denticulate with low teeth, obtuse or subacute, obtuse or rounded at base, distinctly pubescent or subtomentose above, finely pubescent beneath, especially on the prominent reticulated veins; petioles 4–8 mm. long, or the upper leaves nearly sessile; inflorescence of freely branched cymes, terminating the stem and the upper axillary branches and forming a large pyramidal panicle 2.5 dm. in diameter; rameal leaves similar to the cauline but smaller; cyme-branches leafless, straight, bearing three to six sessile, secund, 21-flowered heads; involucre broadly campanulate, 4–5 mm. high, its scales loosely but regularly imbricate, pale green with a darker spot near the tip, ciliate, puberu-

lent on the back, obtuse to broadly rounded at the tip, the midvein becoming prominent near the apex and usually prolonged into a minute mucro; achene minutely pubescent on the ridges; pappus pale tawny, its bristles 4 mm. long, the paleae narrowly linear, about 0.4 mm. long.

TYPE: *Maxon & Hay 3385*, collected on dry plains near Salamá, Guatemala, January 22, 1905, and deposited in the herbarium of the New York Botanical Garden.

*Vernonia salamana* apparently finds its nearest relative in the well-known *V. patens* H.B.K., with which it agrees in its achenes, pappus, involucral scales, olivaceous leaves, and the finely pubescent lower leaf-surface. The shape of the leaf-blade is unlike that of *V. patens* and is closer to that of *V. Deppeana* Less. The pubescence on the upper side of the leaf and the prominent venation are distinctive.

### VERNONIA MOLLIS H.B.K.

A plant collected by the Brothers Seler, number *3371*, has been identified by Hieronymus as *V. mollis* H.B.K. and distributed to American herbaria under that name. Ekman has considered the specimen as *V. canescens* H.B.K., to which it is obviously closely related, but from which it differs in the flat leaves and the tomentose lower leaf-surface, in its involucral scales, which are all subulate, and in its general habit. At the same time, it is doubtful if it is the true *V. mollis*. This is a Colombian species, described as having leaves sericeo-lanuginous beneath. This character is met with in certain Colombian specimens in the New York collections.

### **Vernonia ctenophora** sp. nov.

Stem herbaceous, at least 4 dm. high, finely striate, thinly pubescent and resinous-dotted; leaves sessile or with petioles 2–4 mm. long; leaf-blades thin, ovate-lanceolate, entire, acuminate, obtuse or rounded at the base, as much as 5 cm. long by 2 cm. wide or the upper somewhat smaller, thinly puberulent and conspicuously glandular-dotted above, closely and finely gray-pubescent and resinous on the surface beneath and sparsely pubescent on the midrib and the obscure lateral veins; inflorescence of two or three elongated, erect, terminal or subterminal cymes; bracteal leaves resembling the cauline and progressively smaller, the upper only 15–20 mm. long; heads 20–35 mm. apart, sessile, 18–21-flowered; involucre campanulate,

6–7 mm. high, its scales irregularly but rather closely imbricate, the outer and middle with triangular-ovate or oblong appressed bases and long subulate tips, the inner linear-oblong, rather abruptly acuminate and most of them subulate-tipped, and all thinly pubescent with dark-colored hairs and sparsely resinous; achenes thinly pubescent, sharply ribbed, 1.5 mm. long; pappus white, its bristles 4 mm. long, prominently barbellate, the paleae little wider than the bristles, 0.6 mm. long, sharply ciliate with salient teeth.

TYPE: *E. A. Goldman 508*, collected at Apazota, Campeche, Mexico, December 30, 1900, and deposited in the United States National Herbarium as sheet 396871.

*Vernonia ctenophora* is a member of the species-group *Argyropappae*, as indicated by the resinous-dotted leaves and the long subulate involucral scales. Within the group it is most closely related to *V. hirsutivena* Gleason, from which it is distinguished by the conspicuously barbellate pappus bristles, the sharply ciliate and shorter paleae, the thinly pubescent involucre and achenes, the comparatively thin pubescence on the veins, and the numerous resin-dots on the upper surface of the leaf.

### VERNONIA MISSURICA Raf.

*Vernonia illinoensis* Gleason, Bull. N. Y. Bot. Gard. **4**: 211. 1906.

Throughout its wide range, which is more extensive and covers more diverse environmental conditions than that of any other species in the United States, *V. missurica* exhibits a considerable variation in structure. This variation pertains chiefly to the inflorescence and leaf-pubescence and less to the characters of involucre and achene.

Judged from herbarium evidence and field experience, the species is best developed in Indiana, Illinois, and northern Missouri, where it is by all odds the most common species of the genus. Here the inflorescence is broad, freely branched, with many heads, and relatively flat, and the leaves are thinly but closely tomentose beneath with cinereous multilocular hairs which cover the surface and veins alike. Farther to the northeast, at the border of its range in Michigan and Ontario, the multilocular hairs on the leaf-surface are relatively fewer and usually

replaced by short straight conical hairs. The leaves are smaller and proportionately narrower, and frequently with a basal taper. Because of these structures, the species is frequently mistaken for *V. altissima* Nutt., from which it may be distinguished by the resin-dots on the leaf, involucral scales, and achenes. This extreme form has been described by Daniels under the name *V. michiganensis*, and the same thing from Ontario appears in several herbaria under another unpublished name.

Throughout this whole region, from Michigan to Missouri, the plants exhibit generally rounded to subacute, purple involucral scales, imbricate in relatively few series, and a purple pappus. This is the form described by the writer as *V. illinoensis*.

West of this region the species is much less common, and the herbarium material has been collected in widely scattered localities as far south as southern Texas. In general, the collections from west of the Mississippi and south of the Missouri Rivers have a loose open inflorescence, sharper and frequently smaller involucral scales, imbricate in relatively many series, and frequently green instead of purple, and a pappus which soon becomes tawny in color when exposed to light. But these differences are not constant nor even coincident on the same plant, so that even well-marked varieties can not be accurately distinguished. Yet in four cases out of five the geographical origin can be correctly guessed merely by a glance at the involucre of the plant.

Another area in which a form of the species occurs is the coastal region of southern Mississippi and Alabama. Whether similar plants also occur in southern Louisiana and southeastern Texas is not known definitely, but the inference is that they do. This extreme southeastern form differs in certain features from the species, so that it is recognizable at a glance, and it may be described as a variety.

**Vernonia missurica austroriparia** var. nov.

Inflorescence more or less elongate, very loose, open, irregular, and few-headed; leaf-blades broadest distinctly above the middle, thinly tomentose beneath or merely pubescent; resinous glands on the leaves, scales, and achenes as in the typical form of the species.

TYPE: *Tracy 8015*, collected at Tensaw, Alabama, August 18, 1904, and deposited in the herbarium of the New York Botanical Garden. Other specimens are: *Tracy 6970* from Ocean Springs, Mississippi; *Tracy 4780* from Coopolis, Mississippi; and various specimens collected by Mohr at or near Mobile, Alabama. In some specimens the leaf-pubescence is reduced in amount until the leaf resembles that of *V. altissima*. Such plants have been included under this variety because of the size of the heads, the character of the involucre and inflorescence, and the presence of resin.

**Vernonia aborigina** sp. nov.

Stem herbaceous, stout, striate or ribbed, covered with a brown tomentum becoming thicker above; leaf-blades ovate-lanceolate, remotely denticulate with low ascending callous teeth, acuminate, narrowed below into an obtuse or rounded sessile or subsessile base, 8–15 cm. long, scabrous above with short papillose hairs, densely brown-tomentose beneath; inflorescence rather small and compact, 11–13 cm. wide and bearing relatively few (about 30) heads; bracteal leaves on the cyme-branches lance-oblong, 10–15 mm. long; heads large, in fruit about 12 mm. high, containing in the single head counted 68 flowers; involucre broadly rounded at the base, 7–8 mm. high, expanding to 16–18 mm. wide at maturity; involucral scales closely and regularly imbricated, the outer minute and triangular and all squarrose or recurved at the tip, acute, sparingly ciliate along the brown margin, resinous-glandular and thinly puberulent along the purple central two thirds, elsewhere green and glabrous, tipped with a rather prominent carinate midvein which is frequently prolonged into a short mucro; achenes 3.5 mm. long, olive in color, with low ridges and broad flat furrows, conspicuously glandular in the furrows, minutely and sparsely puberulent on the ridges; pappus-bristles reddish-tawny, almost plumose below, merely barbellate above, 7 mm. long, paleae as long as the diameter of the achene, narrowly linear, equaling in width or barely wider than the bristles.

The type was collected by P. H. Rolfs in Oklahoma, west of Fort Smith, Arkansas, August, 1891, and is deposited in the herbarium of Iowa Agricultural College as sheet number 32272. No other material has been examined.

The description of this new species is offered with considerable reluctance, because of the great variabilty of the western species and their known tendency to hybridize. In several features it differs from all other western species. The large heads, the un-

usual number of flowers in each head, the olive-colored, glandular achenes, and the reddish, conspicuously barbellate pappus distinguish it from all others. The squarrose scales separate it from all others except *V. Baldwini* Torr., the very narrow paleae from all except *V. interior* Small and the species-group *Fasciculatae*. It is to be hoped that further collecting in a somewhat neglected region may bring to light additional material.

**Vernonia fasciculata nebraskensis** var. nov.

Leaves shorter than in the typical form of the species, narrowly lanceolate, denticulate, acute, pale-green or yellowish green; heads closely crowded.

TYPE: *Rydberg 5400*, collected in Kearney County, Nebraska, July 14, 1900, and deposited in the herbarium of the New York Botanical Garden. Numerous other sheets occur in all larger herbaria; in fact, almost all of the Nebraska specimens labeled *V. fasciculata* are to be referred to this variety. The species proper occurs only along the Missouri River, so far as known to the writer, while the variety extends westward more than half the length of the state. Although the brief varietal description apparently offers but little evidence for the separation of a variety, nevertheless the Nebraska specimens in any large herbaria all look alike, all look different from the rest of the species, and can be separated at a glance even by a person not familiar with the genus, as the writer has been able to demonstrate.

VERNONIA ALTISSIMA PUBESCENS (Morris) Daniels

Inner involucral scales tipped with a short, straight, flat, erect, linear tip, not over 2 mm. long.

While Morris's variety was originally separated primarily by the character of the foliage, this is, as has been pointed out by Blake, due to some unusual pathological or teratological condition. The shape of the scales, on the other hand, is found as described above not only in Morris's type but in several other herbarium sheets from the Alleghenian region, from Pennsylvania and Ohio south to Alabama and South Carolina, and in isolated collections of Wilkinson from Mansfield, Ohio.

**Vernonia altissima brevipappa** var. nov.

Lower surface of the leaf-blades with a few multilocular hairs along the veins; paleae only 0.1–0.3 mm. long; otherwise as in the typical form of the species.

TYPE: collected by J. Schneck at Mt. Carmel, Illinois, August 13, 1891, and deposited in the herbarium of the University of Illinois.

**Vernonia altissima laxa** var. nov.

Heads smaller than in the species, 13–21-flowered; inflorescence broad, irregular, very loose and open; inner involucral scales often apiculate, the middle scales frequently sharply acute; resin-dots none; leaf and pubescence as in the typical form of the species.

TYPE: *Harper 1936*, collected at Newton, Georgia, August 19, 1903, and deposited in the herbarium of the New York Botanical Garden; duplicates of the type are in the Gray Herbarium and the herbarium of the Field Columbian Museum. Other specimens of this southern or coastal plain variety are *Tracy 8046* and *Eggleston 5142*.

**Vernonia flaccidifolia angustifolia** var. nov.

Leaves narrowly lanceolate, denticulate, only 1–2 cm. wide; otherwise as in the typical form of the species.

TYPE: *ex herb. Torrey*, collected in Alabama and deposited in the herbarium of Columbia University; another sheet in the New York collections is from Georgia, ex herb. Chapman.

**Vernonia ovalifolia purpurea** var. nov.

Leaves with numerous multilocular hairs on the veins of the lower surface, the upper leaves subtending the branches truncate on rounded at the sessile base; pappus purple; otherwise as in the typical form of the species.

TYPE: *F. S. & E. S. Earle 99*, collected at Auburn, Alabama, July 22, 1899, and deposited in the herbarium of the New York Botanical Garden.

**Vernonia jucunda** sp. nov.

Stem apparently herbaceous, at least 4 dm. high, erect, sparingly branched, densely villous when young, becoming floccose when older and glabrate at about 3 dm. from the summit, faintly

striate and reddish brown under the pubescence; leaf-blades ovate-oblong, as much as 38 × 80 mm., narrowed toward the sessile base or into a short margined petiole, undulate and irregular at the entire margin or rarely with a few low salient teeth, frequently a little revolute, acute at the apex or short-acuminate into a small subulate tip, dark-green and rugose above with impressed veins and scabrous with papillose hairs or hair-bases, gray or nearly white beneath with a close fine tomentum; lateral veins prominent, ascending and straight almost to the leaf-margin; upper and bracteal leaves similar but smaller; heads five-flowered, in a sympodial raceme, standing opposite and a little (2–3 mm.) below a bracteal leaf which later bears secondary heads in its axil, primary heads eight to ten; involucre 8 mm. high, 2.5 mm. wide, with its stiff scales imbricate and appressed at the base and squarrose at the tip, lanceolate-oblong to ovate-oblong, broadest below or near the middle and long-acuminate into a subulate, glabrous, terete, callous tip, the outermost green, one-half the length of the purple inner ones, and all papillose-villous with erect hairs on the exposed portion; corolla apparently pale purple, its tube glabrous, not ampliate above, 5 mm. long, its lobes glabrous, 3 mm. long by 0.6 mm. wide, with parallel sides and triangular tip; filaments glabrous, attached at two thirds the height of the tube; anthers 2.8 mm. long, minutely rounded at the triangular tip, their obtuse bases 0.5 mm. long; style hairy along the upper 1.4 mm., its branches 1.4 mm. long, tapering, hairy on the outer side; achene 2.5 mm. long, shallowly ten-ribbed, pubescent with short erect hairs on the ridges; pappus-bristles pale tawny, 6.5 mm. long, barbellate; paleae linear-lanceolate, 1.0–1.1 mm. long by 0.09–0.18 mm. wide, trough-shaped and pubescent on the inner face.

TYPE: *Purpus 7060*, collected in the Sierra de Tonala of Chiapas, Mexico, October, 1913, and deposited in the herbarium of the University of California as number 173434. Other sheets of the same collection are in other American herbaria and agree in every particular with the type.

*Vernonia jucunda* is the first species of the section *Stenocephalum* to be discovered in North America. Other members of the section are South American; one species, probably undescribed, occurs in Colombia and a number in Brazil. The section is characterized by few-flowered heads set a short distance below the bracteal leaf, by an involucre constricted at the throat and composed of subulate, more or less squarrose scales, and by leaves which are usually revolute and tomentose beneath.

Among the many interesting plants collected by Charles Wright in Cuba, his number 2789, described by Grisebach as *Vernonia lepidota*, is one of the least known. Wright described it as a suffruticose plant, ascending on bushes to a height of about 3 meters, with purple flowers. The Gray Herbarium contains a large specimen which shows the foliar characters very well, but is too immature for a careful study of the floral structures, achenes, or pappus. Ekman examined three sheets of the same number in European herbaria, including Grisebach's type, and has published the first good description of its reproductive structures. A few of his observations have been verified at the Gray Herbarium. Ekman points out that its anthers and styles agree with those of the genus *Vernonia*, but that its pappus is entirely different. The inner pappus is composed of not more than seven flattened bristles, and the outer of scales which are coalescent into a cylindrical tube with lacerose margin. This feature alone is sufficient to warrant the erection of a genus for it, which may appropriately be named in Ekman's honor.

**EKMANIA** gen. nov.

Inflorescence a corymbiform cluster, freely branched and beset with petiolate bract-like leaves; heads homogamous, few-flowered; involucre of a few series of closely appressed scales; corolla glandular without; style and anthers as in *Vernonia*; achene glabrous, ten-ribbed; pappus biseriate, the outer of a cylindrical tube with lacerose margin, the inner of five to seven stout flattened bristles; stem and foliage lepidote.

Type species: *Vernonia lepidota* Griseb.

**Ekmania lepidota** (Griseb.) comb. nov.

*Vernonia lepidota* Griseb. Cat. Pl. Cub. 145. 1866.

Leaf-blades elliptic-oblong, the larger ones 3.5 × 8 cm., the upper smaller, thinly silvery-lepidote above, densely fulvous-lepidote beneath, entire, obtuse or subacute, prominently veined; the larger bracteal leaves petiolate, 10–13 mm. long and one-nerved, the others more crowded distally and gradually reduced in size to short subterete scales 2 mm. long, closely appressed to the involucre and distinguished from it chiefly by their lepidote pubescence; involucre 3 mm. high, its brown scales trough-shaped or boat-shaped, acute, pubescent or scurfy on the back.

**Oliganthes Milleri** (Johnston) comb. nov.

*Vernonia Milleri* Johnston, Proc. Am. Acad. 11: 698. 1905.

The structure of the pappus of this little-known species from the island of Margarita indicates clearly its affinity with *Oliganthes* rather than with *Vernonia*.

**Piptocoma rufescens latifolia** var. nov.

Leaf-blade narrowly ovate or elliptic, two to three times as long as wide, broadly obtuse or rounded at the apex, abruptly narrowed at the base, its tomentum loose and thin; petiole 1 cm. long; involucre larger and its scales more tomentose than in the typical form of the species.

TYPE: *Britton, Britton & Shafer 104*, from a coastal thicket on Water Island, St. Thomas, January 31 to February 4, 1913, and deposited in the herbarium of the New York Botanical Garden; a second sheet in the same collection is *Britton & Shafer 845*, from a coastal thicket on Salt Island, Tortola.

The species of *Elephantopus* occurring in the southeastern United States have long been a difficult problem for taxonomists. *E. carolinianus* Willd. and *E. nudatus* Gray are quite distinct and have generally been recognized. Gray, in the Synoptical Flora, in 1886, combined *E. tomentosus* L. with *E. elatus* Bertol., and in general Bertolini's species was not recognized until 1901. Baker then regarded it as distinct and gave some valuable comparative measurements. While the difference in length of involucral scales and pappus is distinct in mature heads, it is not always reliable at earlier stages. Possibly for this reason, Baker's measurements have been neglected by recent authors, and Small has separated the two species chiefly on characters of leaf and pubescence, which are unfortunately exceedingly variable.

One diagnostic character has however been overlooked. In *E. tomentosus* the hairs on the midvein are generally reflexed, while on the leaf-surface proper many or all of the hairs point backward. In *E. elatus* the hairs of the midvein are longer and stiffer and point distinctly forward. Separated by this character, many specimens usually referred to *E. tomentosus* are found to belong to the other species, having also the short, heavily invested scales

and short pappus ascribed by Baker to *E. elatus*, and only the leaf-shape of *E. tomentosus*. These may be described as a variety.

**Elephantopus elatus intermedius** var. nov.

Leaf-blade elliptic or oblong, abruptly narrowed to the base, less than three times as long as wide; stem comparatively short and sparingly branched; pappus sometimes as much as 5 mm. long.

TYPE: *Tracy 4741*, collected at Coopolis, Mississippi, September 8, 1898, and deposited in the herbarium of the New York Botanical Garden. The variety is represented in herbaria by numerous specimens, and is distributed from southern Mississippi east along the coastal plain to Georgia and south to Lee and Dade Counties in southern Florida.

NEW YORK BOTANICAL GARDEN

# Storied or tier-like structure of certain dicotyledonous woods*

SAMUEL J. RECORD

A considerable number of dicotyledonous woods are characterized by a storied or tier-like arrangement of their secondary elements. Such woods exhibit on longitudinal section, typically on the tangential, fine transverse lines, bands or striations commonly called "ripple marks." These markings may be distinct to the unaided eye, may be at or near the limit of vision, or may require the lens. In some cases they may be more readily seen without the lens than with it, or they may be fairly distinct under the lens but indistinct or apparently absent under the compound microscope. In specimens with very dark and infiltrated heartwood the markings may be obscured there but show plainly in the sapwood; usually, though, they appear to best advantage in the heartwood.

In woods with this type of structure the cambial cells are in tangential as well as radial seriation and part or all of the elements to which they give rise preserve this arrangement. Ordinarily it is only in stems of considerable thickness that the tiers assume a marked regularity, but the diameter a stem must attain before the storied structure becomes pronounced is subject to wide variation, depending not only on the species but also on the rate of growth. In certain stems of Leguminosae and Zygophyllaceae the tiers were found to be fairly regular in what was apparently the second annual ring, less than one eighth inch from the pith. In general, though, this feature is wanting in the twigs of herbarium material.

The storied structure may not extend to all of the elements. In the extreme and also the most common form (Zygophyllaceae, Bignoniaceae, Leguminosae in large part, and others) the rays, vessel segments, tracheids, wood fibers, and wood parenchyma strands are all in horizontal seriation. On the tangential surface the cross sections of the rays appear as short, closely spaced, par-

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allel lines, often of very regular length and arrangement, while separating the tiers is a fine line of lighter or darker shade than the remainder of the wood. These lines are made by the junctions of the tiers of wood cells and vary in appearance according to the elements involved in a particular area, whether fibers with interlacing tips or vessel segments and wood parenchyma cells with abrupt terminations. In some instances, also, the local aggregations of pits in the fiber walls where the lumina become constricted tend to increase the refraction there and make the lines more distinct. According to Von Höhnel (1, p. 33) this is very pronounced in *Bocoa provacensis* Aubl. (*Inocarpus edulis* Forst.); his findings are confirmed by Wiesner (5, pp. 15, 950), who figures the pits. In the cases investigated by the present writer such pit-areas were noted in several woods, as for example, in *Machaerium*, *Physocalymma*(?), and *Erythrina*.

Where the rays are all storied they occupy the median portion of each tier, the height of which is usually considerably greater than the height of the rays. Consequently there is room for considerable variation in the height of the rays without interrupting the regularity of the transverse markings. It is not uncommon to find some of the rays grown together at the margins and thus occupying two or three stories, as for example, in *Cercis*, *Crescentia*, *Ormosia* and *Ougenia*. Where the rays are in perfect seriation, a section between two tiers misses them completely. In most instances, however, such a section shows rayless gaps, the width of which depends upon the regularity of stories.

In some storied woods, especially in the Bombacaceae, Malvaceae and Sterculiaceae, the rays are of two general sorts, large and small. Here only the low rays are in seriation and they may be so few, comparatively, and so over-shadowed by the large rays that the "ripple marks" are indistinct except in proper light and may be easily overlooked in casual inspection. In some of these woods the markings may be plainer without the lens than with it and, because of the very limited field under observation, may not be distinguishable at all under the compound microscope.

In both of these types the elements other than the rays are normally storied. The vessel segments and vascular tracheids correspond in length to the height of each tier, though occasional

short segments are found which appear to be subdivisions. The wood parenchyma strands show a uniformity in length with the vessel segments, but in a few cases where parenchyma is scanty the vessel segments and tracheids (when present) seem to be entirely responsible for the "ripple marks." This was found to be the case in *Dalea spinosa* Gray, *Artemisia tridentata* Nutt., and *Bigelovia graveolens* Gray.

The number of parenchyma cells per strand is not constant but in most of the woods investigated was found to be two or four; sometimes only one (an intermediate or substitute fiber). It is not uncommon to find that the metatracheal strands are composed of two cells and the paratracheal of four. Where the parenchyma is abundant, the component cells of the strands may be uniformly disposed and thus give rise to a secondary seriation which, especially if the cells are large, is readily visible under the lens. In this case the height of the tiers in only one half or one fourth that of the ordinary tiers. In species of *Bombax*, *Ceiba* (*Eriodendron*) and *Heliocarpus* the number of cells per strand is four; in *Charpentiera*, *Diphysa* and *Lonchocarpus*, two; in *Gossypium* and *Pterocymbium*, two in the metatracheal and four in the paratrachea[1]. The same structure obtains in some of the finer-textured woods, but the small size of the cells usually renders it indistinct or invisible under the lens. It was found fairly distinct in *Ichthyomethia piscipula* (L.) Kuntze (mostly two cells per strand) and less so in *Tabebuia Guayacan* Hemsl. (four cells per strand).

The libriform fibers and fiber-tracheids (collectively, wood fibers) may or may not show distinct seriation in the tangential section. In all ordinary cases the fibers are much longer than the vessel segments or the height of the tiers. In many cases there is a widened middle portion equal to about one third of the total length of the fiber and corresponding to the length of the original cambial cell. The attenuated ends of the fibers of one tier are forced during elongation between the fibers of the tiers immediately above and below and, in consequence, a cross section through the middle portion of a tier will show (under the compound microscope) alternate rows of large and small cells, the latter being twice as many as the large ones. A section through the junction of two tiers will show fewer cells and they will be more nearly uniform

in size. In many woods the fibers show a gradual instead of abrupt diminution in caliber and the feature just mentioned is absent or indistinct. It may require careful maceration to determine whether or not the fibers are storied, particularly in woods with irregular rays. The fact that the fibers are so interlaced and dove-tailed together prevents woods with storied structure from being weakened or made brittle thereby.

In *Herminiera elaphroxylon* Guill. & Perr., the wood cells ("palisade tracheids" of Jaensch, **3**, p. 269) are parenchymatous and arranged in regular stories. Some of the cells are subdivided but not very regularly. The low uniseriate rays are storied while the large ones (which may contain vessels) are not. The vessel segments are mostly of the same length as the height of the tiers but according to Wiesner (**5**, p. 20) some of them may be subdivided. The wood fibers, which are distributed in narrow layers, are three times the length of the other elements and have localized pit areas at the constrictions. Solereder (**6**, p. 276) figures *Aeschynomene* sp. with the parenchymatous wood cells much pitted at the ends. The present writer did not have opportunity to study woods of this genus but found much the same structure in *Erythrina* spp., except that all or nearly all of the rays are large and the wood fibers in the scattered bands are apparently not storied. The parenchymatous cells making up the ground mass are large, thin-walled, blunt-ended, and usually subdivided into two cells about the vessels. The markings vary from distinct in some specimens to barely visible without lens in others.

Where the elements of the wood are definitely storied it is, of course, to be expected that the same arrangement will likewise appear in the secondary phloem. In the limited number of stems with bark examined by the writer this was found to be the case and in some instances, *Dalea spinosa* for example, the feature was more distinct on the inner surface of the bark than in the wood. An unusual case was found in *Olneya tesota* Gray, where the inner surface of the bark exhibits, under the lens, fine but distinct and fairly regular cross-lines (150–160 per inch) without, apparently, any corresponding structure in the wood. Under the compound microscope the vessel segments and wood parenchyma strands are indistinctly storied, but the rays and apparently the fibers are

not, while the vertical elements of the secondary phloem are in horizontal seriation. The distinctness of the cross-lines in the inner layers of phloem was found to be largely due to highly refractive callus on the sieve plates.

The storied structure of wood occurs throughout a considerable range of families and orders as will appear from the following list, which is arranged according to the Engler and Gilg (1912) system of classification. The first numeral following the family refers to the number of different genera in which the feature has been noted by the writer; that in parentheses, to the total number reported.

1. URTICALES: Ulmaceae, 1 (1); Moraceae, 1 (1).
2. CENTROSPERMAE: Amarantaceae, 1 (1).
3. RHOEADALES: Moringaceae (1).
4. ROSALES: Rosaceae (1?); Leguminosae, 40 (51).
5. GERANIALES: Zygophyllaceae, 3 (4); Rutaceae, 1 (1); Simarubaceae, 3 (4); Meliaceae, 6 (7).
6. SAPINDALES: Hippocastanaceae, 1 (1); Sapindaceae (1).
7. MALVALES: Tiliaceae, 5 (8); Malvaceae, 4 (4); Bombacaceae, 3 (3); Sterculiaceae, 7 (8).
8. MYRTIFLORAE: Lythraceae, 1? (1?).
9. EBENALES: Ebenaceae, 1 (1).
10. TUBIFLORAE: Bignoniaceae, 3 (3).
11. CAMPANULATAE: Compositae, 3 (3).

Consideration of the above list leads to the conclusion that there is no close correlation between the form of wood structure under consideration and the various types of floral organization which serve as the basis for the classification followed. There seems to be a correlation, however, between this storied structure and certain types of differentiation of the wood elements. The vessel segments have abrupt ends and simple perforations, and the elongated or scalariform type of pitting is rarely found and then only in the tracheidal vessels and vascular tracheids. The wood fibers are for the most part provided with simple pits or with pits having only small and indistinct borders. The pits between vessels and parenchyma are usually small and half-bordered. It is also interesting to note that with very few exceptions (notably *Aesculus*, *Cercis*, *Cytisus*, *Diospyros* and *Tilia*) the woods are of tropical or subtropical origin.

There is no family, with the possible exception of the Zygo-

phyllaceae (only a few woods of which were studied), in which all of the woods are characterized by horizontal ranking of their elements. In many cases it appears to be a generic character but more often it is specific only. A few instances have been noted where the feature is not constant for a given species and may be of only local occurrence in the same specimen. One of the best examples of this is furnished by *Swietenia*, where "ripple marks" exhibit wide variation in regularity and occurrence and are about as likely to be absent as present. In general, however, the constancy of the feature seems to bear a direct relation to the degree of regularity of the cross-markings. It is most dependable when all of the elements are involved and especially when the rays are fine and of uniform height.

In this investigation attention has been given to the elements storied, the regularity and visibility of the transverse markings and to the height of the tiers in each wood examined. In most instances only the gross and lens characters are given since they are most readily employed in practice. There are so many factors entering into the question of distinctness or visibility that the particular observations of the writer may not always apply. For instance, in *Guaiacum* the markings, though extremely fine, are distinct under the lens in the sapwood and may be indistinct or even invisible in very resinous heartwood. Usually the visibility is materially increased by moistening the surface, but in some instances the opposite effect is produced.

According to Von Höhnel (**2**, p. 2) the distance between the cross-lines varies from one half to one eleventh of a millimeter, and for a given species is constant. In order to determine whether or not there is a definite tier-height for each species the present writer counted the number of tiers per inch of length on the tangential section of every specimen examined. An inch, divided into quarters, was marked off and the count and recounts made under the lens for the entire inch, the quarter-marks serving as an additional check. In the larger specimens, at least two different inches were counted. In some instances the markings, being fairly distinct without a lens but indistinct with it, were counted with the naked eye or with the aid of a reading-glass. Where the rays are not in seriation the cross-lines are likely to be

indistinct, and the most satisfactory results can be secured by counting the vessel segments. In the Zygophyllaceae the lines, though very uniform and readily visible under the lens, are so very closely spaced (about 250 per inch) that is it practically impossible to make an accurate count without the use of the compound microscope. By using low power and reflected light the smooth surface of a small specimen can be readily examined and measurements made without preparing thin sections.

Considerable variation in tier-height was found not only in different specimens of the same species but also in the same specimen. Even within a given inch of length the number per quarter may show a variation of from two to five as a result of the occasional to frequent bifurcation of the tiers, with consequent narrowing at the point of branching. The greatest variation in tier height within a species was noted in *Diospyros virginiana* L., where the counts per inch on eleven different specimens were as follows: 57, 57, 58–60, 60, 61, 62, 63, 66–68, 70–72, 72–74, 81–82; a maximum difference of 25 per inch, or nearly 45 per cent on the basis of the minimum. In only one other case did the variation exceed 20 per cent, and almost always it was less than 10 per cent.

In 86 woods of the Leguminosae the number of markings per inch were as follows: under 100, 29 per cent; 100 up to 125, 34 per cent; 125 up to 150, 21 per cent; 150 to 190, 12 per cent. Nearly every wood showing between 125 and 190 "ripple marks" per inch belongs to the Leguminosae. The investigated woods of the Zygophyllaceae have considerably more than 200 per inch, mostly about 250, and may, by means of this feature alone, be readily separated from all of the others. This fact has proved of practical value in distinguishing the wood of true lignum-vitae from its various substitutes.

The present investigation fails to confirm certain findings of other writers. Von Höhnel (1, p. 38) states that the rays are storied in *Parkinsonia*, but there was no evidence of this in the specimens examined by the writer. The grenadillo wood is referred to as "*Inga vera* W.?" (p. 39) but this is probably incorrect, inasmuch as various specimens of *Inga* spp. were found to be without any tendency to storied structure. The name "grenadillo" is applied to several woods, one of which is *Brya Ebenus* DC. Another wood with "ripple marks" was provisionally identified

by the same author as *Conocarpus erecta* (Combretaceae), but authentic specimens of this species are wholly without this structure, as are all other representatives of the family that were examined. Wiesner (**5**, p. 997) states that in *Olea europea* L. the rays (under the lens) produce a fine wavy cross-striping on the tangential section. Specimens of the wood examined by the writer exhibit no tendency to "ripple marks," and Müller (Atlas der Holzstructur, 1888, pp. 88, 91) gives as one of the distinguishing features of this wood the irregularity in size of the rays. All of the foregoing woods are excluded from the table given below.

The only representative of the Lythraceae included in the list is *Physocalymma scaberrimum* Pohl, variously known as Brazilian tulip-wood, rose wood, "páo de rosa," "cego machada," "grão de porco" and "sebastião de arruda." Writers all seem to be in agreement in referring this wood to the species mentioned, but the specimens examined by the writer, which are evidently the same as those described by Wiesner (**5**, p. 975), appear to belong to the Leguminosae. They certainly do not resemble other available material of the Lythraceae.

Another wood of which there is some doubt is *Ferolia guyanensis* Aubl. (= *Parinarium* sp.) of the Rosaceae, mentioned by Von Höhnel (**1**, p. 43), who calls it "Ficatin- oder Königsholz." According to Stone (Timbers of Commerce, 1904, p. 101) this species supplies the wood from Guiana commonly known as "washiba" or bow-wood. Authentic specimens of washiba and bow-wood, collected by the Forestry Officer of British Guiana are *Tabebuia* spp. The tier height in the latter is about 0.25 mm., while according to Von Höhnel the height of the "Markstrahlstockwerke" in the wood of *Ferolia* is about 0.15 mm. If Von Höhnel's measurement refers only to the height of the rays the discrepancy disappears, since this agrees closely with the writer's observations. No other wood of the Rosaceae has been reported as having a tier-like structure.

The satinwood, *Chloroxylon Swietenia* DC., is listed with the Rutaceae (following Engler), rather than with the Meliaceae, because the wood so closely resembles those of the Rutaceae and has so little in common with the others. No other representative of the Rutaceae has been found with storied structure, while various representatives of the Meliaceae exhibit a more or less

pronounced tendency in this direction. It is interesting to note, however, that the number of tiers per inch in the latter woods (so far as known to the writer) is between 45 and 55, while in the satinwood it is about 80.

Most of the woods with "ripple marks" belong to the Leguminosae. Following is a list of woods examined by the writer in which the storied structure was not observed, though a few (marked with an asterisk) have been reported by other writers and are included in the list. Some of the more common synonyms are placed in parentheses. These woods are: *Adenanthera, Albizzia*, Bowdichia* (?), *Browneopsis, Cassia*, Cercidium, Cercidophyllum, Cladastris* (*Copaiba*), *Copaifera, Cynometra, Daniellia* (?), *Dimorphandra, Enterolobium, Erythrophloeum, Eysenhardtia, Gleditsia, Gymnocladus, Haematoxylon, Inga* (see page 259), *Intsia, Kingiodendron* (?), *Lysiloma, Mimosa, Pahudia, Parkia*, Parkinsonia, Peltogyne, Peltophorum* (?), *Piptadenia, Pithecolobium, Prioria, Prosopis, Pterodon, Robinia, Sindora* (*Vouacapoua*), *Zygia* (?).

In this investigation all of the woods in the extensive collections of the Yale School of Forestry were gone over. Since many of these are from tropical regions, of which our botanical knowledge is far from complete, it is by no means certain that all of the specific identifications are correct, though special effort was made to eliminate errors or indicate the doubtful cases. A considerable number of woods, mostly belonging to the Leguminosae, have been omitted because their botanical status has not been determined. The following table is published with a view of calling attention to an important feature of wood structure and with the hope of stimulating further investigation in this direction. The writer will appreciate assistance in correcting and extending the data.

NOTES: Under "rays not storied" are included woods which may have some of the rays, the small ones, in horizontal seriation. "Wood parenchyma cells storied" refers to the secondary seriation produced by the individual cells of the wood parenchyma strands; not visible without lens. "Fiber pits storied" refers to the horizontal seriation of special pit areas on the wood fibers. Where not noted does not necessarily mean that the feature is absent, since not all of the woods were examined microscopically. "Number of tiers per inch" applies exclusively to measurements by the writer and is the basis for "tier-height." A dash indicates a tendency. Data from other writers are credited to them and are as nearly complete as their descriptions will permit.

TABLE OF WOODS WITH TIER-LIKE STRUCTURE, SHOWING THE ELEMENTS STORIED, THE REGULARITY AND VISIBILITY OF THE TRANSVERSE LINES ("RIPPLE MARKS"), AND MEASUREMENTS OF TIER-HEIGHT

| Scientific name | Common name | Country | Elements storied | | | | Regularity of lines | | | | Visibility | | | | Measurements | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | All elements | Rays not storied | Wood parenchyma cells storied | Fiber pits storied | Regular | Fairly regular | Irregular | Local occurrence | Distinct—fairly so | Barely visible | Lens required | Indistinct with lens | Tier-height in mm. | Number of tiers per inch |
| **AMARANTACEAE** | | | | | | | | | | | | | | | | |
| CHARPENTIERA OVATA Gaudich. | Papala | Hawaii | | × | × | | | × | | | | | × | | 0.22–0.23 | 110–115 |
| **BIGNONIACEAE** | | | | | | | | | | | | | | | | |
| CRESCENTIA CUCURBITINA L. | Black Calabash | Florida | × | | | | | | × | | | × | | | 0.22–0.23 | 110–115 |
| " CUJETE L. | Calabash | Porto Rico | × | | | | | | × | | | × | | | 0.21–0.22 | 115–120 |
| TABEBUIA DONNELL-SMITHII Rose | Prima vera | Central America | × | | | | | × | — | × | | × | | | 0.25 | 100 |
| " GUAYACAN Hemsl. | Yellow guayacan | Panama | × | | × | | × | | | | × | | | | 0.28 | 90– 92 |
| " NODOSA Griseb. | Toro-ratai | Argentina | × | | | | | × | | | | × | | | 0.17–0.18 | 140–145 |
| " PALMERI Rose | Amapa prieto | West coast Mexico | × | | | | × | | | | | × | | | 0.20 | 124 |
| " PENTAPHYLLA Hemsl. | (Roble) | Panama | × | | | | | × | | | × | | | | 0.29 | 84 |
| " SCHUMANNIANA Urb. | Roble colorado | Porto Rico | × | | | | | | × | | × | | | | 0.29–0.31 | 80– 85 |
| " sp. (No. 58) | Roble | Honduras | × | | | | — | × | | | × | | | | 0.26–0.28 | 90– 96 |
| " sp. (No. 97) | " | " | × | | | | | × | | | × | | | | 0.30 | 84 |
| " sp. (No. 378) | " | Colombia | × | | | | × | | | | × | | | | 0.32–0.33 | 76– 78 |
| " sp. (No. 351) | Apamate | Venezuela | × | | | | | × | | | × | | | | 0.32 | 78 |
| " sp. | Hackia | British Guiana | × | | | | × | | | | × | | | | 0.26 | 94– 96 |
| " sp. | Washiba Bow-wood | " | × | | | | × | | | | × | | | | 0.24 | 102–103 |
| TECOMA ARALIACEA DC. | Surinam Groenhart | " | × | | | | × | | | | × | | | | 0.33 | 74 |
| " CHRYSANTHA DC. | Araguaney | Venezuela | × | | | | × | | | | | × | | | 0.21–0.22 | 115–120 |
| " LEUCOXYLON Mart. | Roble | Porto Rico | × | | | | | | × | | | | × | | 0.24–0.25 | 100–105 |
| " OBTUSATA DC. (*T. Ipe* Liais) | Lapacho | Argentina | × | | | | × | | | | | × | | | 0.21 | 120 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TECOMA SPECIOSA DC. (Höhnel, 1, p. 41) | | | × | | | × | × | | | | | | 0.25 | |
| " STANS Juss. | | West Indies | × | | | | | | × | | × | | 0.21 | 120 |
| " sp. (No. 930) | Lapacho | Argentina | × | | | | × | | | | × | | 0.22–0.23 | 112–115 |
| " sp. (No. 1124) | " | " | × | | | | × | | | | × | | 0.24 | 105–107 |
| " sp. (market specimen) | Bethabara | ? | × | | | | × | | | | × | | 0.28 | 90 |
| " sp. (2 specimens) | | Brazil | × | | | | × | | | × | | | 0.25–0.26 | 95–100 |
| **BOMBACACEAE** | | | | | | | | | | | | | | |
| BOMBAX CYATHOPHORUM (Casar.) K. Schum. (*Pachira cyathophora* Casar.) | Imbirussi | Brazil | | × | × | | | × | | | × | | 0.63–0.71 | 35– 40 |
| BOMBAX INSIGNE Wall. | Didu | Andamans | | × | × | | | × | | | × | | 0.42–0.43 | 58– 60 |
| " sp.? (No. 503) | Tolu | Colombia | — | × | | | | × | | | × | | 0.40 | 63 |
| " sp.? (No. 1570) | Majagua | " | | × | | | | × | | | × | | 0.42–0.45 | 55– 60 |
| CEIBA PENTANDRA (L.) Gärtn. (*Eriodendron anfractuosum* DC.) | Ceiba | Cuba | | × | × | | | × | | | × | | 0.42 | 70 |
| CUMINGIA PHILIPPINENSIS Vidal | Gapas-gapas | Philippine Islands | × | | | | × | | | × | | | 0.33 | 75 |
| **COMPOSITAE** | | | | | | | | | | | | | | |
| ARTEMISIA TRIDENTATA Nutt. | Sage Brush | California | | × | | | | × | | | | × | 0.13 ± | 200 ± |
| BACCHARIS SAROTHROIDES Gray | | " | | × | | | | × | | | — | × | 0.20–0.21 | 120–125 |
| BIGELOVIA GRAVEOLENS Gray | | Colorado | | × | | | | × | | | | × | × 0.13 ± | 200 ± |
| **EBENACEAE** | | | | | | | | | | | | | | |
| DIOSPYROS VIRGINIANA L. (11 specimens) | Persimmon | Eastern United States | × | | | | × | — | × | | × | | 0.30–0.44 | 57– 82 |
| **HIPPOCASTANACEAE** | | | | | | | | | | | | | | |
| AESCULUS OCTANDRA Marsh. (*A. flava* Ait.) | Buckeye | Central United States | × | | | | | × | × | | × | | × 0.36–0.43 | 58– 68 |
| **LEGUMINOSAE** | | | | | | | | | | | | | | |
| ALBIZZIA PROCERA (Willd.) Benth. (*Acacia procera* Willd.; Höhnel, 1, p. 38) | | Tropical Asia | × | | | | | | | | | | 0.20 | |
| AESCHYNOMENE sp. (Solereder, 6, p. 275) | Solah | India | | × | | × | | × | | | | | | |
| ANDIRA ANTHELMINTHICA Benth. (Höhnel, 1, p. 35) | | Brazil? | × | | | | × | | | | | | 0.25 | |

TABLE OF WOODS WITH TIER-LIKE STRUCTURE, SHOWING THE ELEMENTS STORIED, THE REGULARITY AND VISIBILITY OF THE TRANSVERSE LINES ("RIPPLE MARKS"), AND MEASUREMENTS OF TIER-HEIGHT—*Continued*

| Scientific name | Common name | Country | Elements storied | | | | Regularity of lines | | | | Visibility | | | | Measurements | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | All elements | Rays not storied | Wood parenchyma cells storied | Fiber pits storied | Regular | Fairly regular | Irregular | Local occurrence | District—fairly so | Barely visible | Lens required | Indistinct with lens | Tier-height in mm. | Number of tiers per inch |
| LEGUMINOSAE—*Continued* | | | | | | | | | | | | | | | | |
| ANDIRA INERMIS H. B. K. | Yaba | Cuba | × | | | × | | × | | | | × | | | 0.26 | 93- 96 |
| " " (Wiesner, **5**, p. 947) | Partridge Wood | Tropical America | × | | | | × | | | | | | × | | | |
| APULEIA PRAECOX Mart. | Ibira pere | Argentina | × | | | | × | | | | × | | | | 0.24–0.26 | 95–105 |
| " " | " " | " | × | | | | × | | | | × | | | | 0.28–0.29 | 85- 90 |
| " sp. (No. 2497) | Faviero | Brazil | × | | | | × | | | | × | | | | 0.26 | 95 |
| ARTHROCARPUM GRACILE Balf. f. (Saupe, **4**) | | | | | | | | | | | | | | | | |
| BAPHIA NITIDA Lodd. (Wiesner, **5**, p. 936) | Camwood | Tropical Africa | × | | | | × | | | | | | × | | | |
| BAUHINIA LIGULATA Pittier | | Panama | × | | | | | × | | | × | | | | 0.22–0.23 | 110–115 |
| " RETICULATA DC. (Höhnel, **1**, p. 37) | | Africa? | × | | | | × | | | | | | | | | |
| BELAIRIA MUCRONATA Griseb. | Yamaquey | Cuba | × | | | | × | | | | | | × | | 0.13–0.14 | 180–190 |
| " SPINOSA A. Rich. | " | " | × | | | | × | | | | | | × | | 0.14 | 175–180 |
| BRYA EBENUS DC. | Green Ebony | West Indies | × | | | | × | | | | | | × | | 0.15–0.16 | 160–165 |
| CAESALPINIA CORIARIA Willd. | Divi-divi | Curaçao | × | | | | × | | | | × | | | | 0.21–0.23 | 110–120 |
| " " | " | " | × | | | | | | | × | | × | | | 0.18 | 136 |
| " " | " | India | × | | | | × | | | | × | | | | 0.19–0.20 | 126–132 |
| " EBANO Karst. | Pao ferro | Brazil | × | | | | × | | | | × | | | | 0.25–0.26 | 95–100 |
| " ECHINATA Lam. | Brazil-wood | " | × | | | | | | × | | | × | | | 0.28 | 90 |
| " MELANOCARPA Griseb. | Guayacan | Argentina | × | | | | × | | | | | | × | | 0.18–0.19 | 130–135 |
| " " ? | " | " | × | | | | × | | | | | × | | | 0.17–0.18 | 140–145 |
| " SAPPAN L. | Sappan-wood | Philippine Islands | × | | | | | | × | × | | × | | | 0.26 | 95 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CAESALPINIA TINCTORIA Domb. (Höhnel, 1, p. 37) | | West Indies? | × | | | | × | | | | | | 0.33 | |
| CASSIA FISTULA L. (Höhnel, 1, p. 37) | | India? | × | | | | × | | | | | | 0.17 | |
| CASTANOSPERMUM AUSTRALE A. Cunn. & Fraser | Black Bean | Australia | × | | | × | | — | × | × | × | | 0.31–0.33 | 75–80 |
| CENTROLOBIUM PATINENSE Pittier | Amarillo de Guayaquil | Panama | × | | | × | | | | | × | | 0.23–0.24 | 105–110 |
| " ROBUSTUM Mart. | | Colombia | × | | | × | | | | | × | | 0.23 | 110 |
| " sp. ? (ten specimens) | Arariba | Brazil | × | | | × | | | | | × | | 0.21–0.25 | 100–200 |
| " sp. ? | Guayacan Jobo | South America | × | | | | | | | | | | 0.25 | 100 |
| CERCIS CANADENSIS L. | Redbud | Central United States | × | — | | | × | | | | | × | 0.16–0.17 | 150–160 |
| " SILIQUASTRUM L. (Wiesner, 5, p. 930) | Judas Tree | Europe | × | — | | | × | | | | × | × | 0.20–0.24 | |
| COUMAROUNA ODORATA Aubl. | Tonka Bean | British Guiana. | × | | | × | | | | × | | | 0.31 | 80 |
| " PANAMENSIS Pittier | | Panama | × | | | × | | | | × | | | 0.30 | 82 |
| " sp. | Coumaru | Trinidad | × | | | × | | | | × | | | 0.28 | 90 |
| DALBERGIA BROWNEI Schinz. | | Florida | × | | | | × | | | | × | | 0.21 | 120 |
| " HUPEANA Hance | | China | × | | | | × | | | | × | — | 0.18 | 135–140 |
| " LATIFOLIA Roxb. | Rosewood | India | × | | | | | | | | | | 0.16–0.17 | 150–160 |
| " NIGRA Allem. (Höhnel, 1, p. 37) | | Brazil? | × | | | × | × | | | | × | | 0.20 | |
| DALBERGIA RETUSA Hemsl. | Cocobola | Panama | × | | | | × | | | | × | | 0.18 | 138–140 |
| " sp. ? (two specimens) | " | Honduras | × | | | × | | | | | × | | 0.18–0.19 | 132–140 |
| " Sissoo Roxb. | Sissoo | India | × | | | | × | — | | | | × | 0.16 | 155–158 |
| DALEA SPINOSA Gray | Indigo Bark | Southwestern United States | | × | | | | | | | | | 0.17 | 150 |
| DIALIUM INDUM L. (Höhnel, 1, p. 36) | | Java? | × | | | | | | | | | | 0.33 | |
| DIPHYSA CARTHAGENENSIS Jacq. | | Panama | | × | × | × | × | × | — | | | × | — | 0.16 | 155–160 |
| ENTEROLOBIUM SCHOMBERGKII Benth. | | " | × | | | | | | × | × | | | × | |
| " sp. ? | Piñon | Colombia | × | | | | | × | | × | | | × | 0.33 | 75 |
| ERYTHRINA CRISTA-GALLI L. | | Brazil | | × | | × | × | | | × | | | × | 0.18 | 135–140 |
| " FALCATA Benth. | Ceibo | Argentina | | × | | × | × | | × | × | | | × | | |
| " INDICA Lam. | Dap-dap | Philippine Islands | | × | | × | × | | | × | | | | 0.26–0.28 | 90– 95 |
| " MONOSPERMA Gaudich. | Wili-wili | Hawaii | | × | | × | × | | | | — | × | | 0.19–0.20 | 125–130 |
| " aff. VELUTINA Willd. | | Curaçao | | × | | × | × | | | — | × | | | 0.19 | 130 |

TABLE OF WOODS WITH TIER-LIKE STRUCTURE, SHOWING THE ELEMENTS STORIED, THE REGULARITY AND VISIBILITY OF THE TRANSVERSE LINES ("RIPPLE MARKS"), AND MEASUREMENTS OF TIER-HEIGHT—*Continued*

| Scientific name | Common name | Country | Elements storied | | | | Regularity of lines | | | | Visibility | | | | Measurements | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | All elements | Rays not storied | Wood parenchyma cells storied | Fiber pits storied | Regular | Fairly regular | Irregular | Local occurrence | Distinct—fairly so | Barely visible | Lens required | Indistinct with lens | Tier-height in Mm. | Number of tiers per inch |
| LEGUMINOSAE—*Continued* | | | | | | | | | | | | | | | | |
| GENISTA CANARIENSIS L. (Höhnel, 1, p. 38) | | | × | | | | | | | | | | | | | |
| GOURLIEA DECORTICANS Gill. (four specimens) | Chañar | Argentina | × | | | | × | | | | | | × | | 0.13–0.15 | 165–185 |
| HERMINIERA ELAPHROXYLON Guill. & Perr. (Jaensch, 3, p. 268) | Ambatsch | India | | × | | × | | × | | | | | × | | 0.22–0.23 | |
| HOLOCALYX BALANSAE Micheli | Alecrin | Argentina | × | | | | × | | | | | × | | | 0.20–0.21 | 120–125 |
| ICTHYOMETHIA PISCIPULA (L.) Kuntze | Jamaica Dogwood | Florida | × | | × | | × | — | | | | | × | | 0.17–0.18 | 140–150 |
| INDIGOFERA ZOLLINGERIANA Miq. | | Philippine Islands | × | | | | | | × | | | × | — | | 0.18 | 135 |
| INOCARPUS EDULIS Forst. (Höhnel, 1, p. 33) | Boko or Coco Wood | Guiana | × | | | × | × | | | | × | | | | 0.33 | |
| KOOMPASSIA EXCELSA Teub. | Manggis | Philippine Islands | × | | | | | × | | | × | | | | 0.55–0.60 | 42– 45 |
| LABURNUM VULGARE J. Presl (Wiesner, 5, p. 940) | Goldregen | Europe | | × | | | | | | | | | | | | |
| LONCHOCARPUS ALBIFLORUS G. Don | Robo blanco | Argentina | × | | × | | × | | | | | × | | | 0.21 | 118–121 |
| MACHAERIUM WHITFORDII Macb. | Negrillo | Colombia | × | | | × | × | | | | | | × | | 0.17–0.18 | 140–145 |
| " sp.? (*Dalbergia?*) | Jacaranda roxo | Brazil | × | | | | | × | | | | | × | | 0.19 | 128 |
| " sp.? (*Dalbergia?*) | Jacaranda mulatto | " | × | | | | | × | | | | × | | | 0.19 | 128 |
| " sp.? (*Dalbergia?*) | Jacaranda | " | × | | | | | × | | | | | × | | 0.18 | 136 |
| MEZONEURUM KAUAIENSE Hillebd. | Uhi-uhi | Hawaii | | × | | | | | × | | | × | | | 0.23–0.25 | 100–110 |
| MILLETIA PENDULA Benth. | | India | × | | | | × | | | | × | | | | 0.24–0.25 | 98–104 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MYROCARPUS FASTIGIATUS Allem. | Incienso | Argentina | × | | | × | | | × | | | 0.26 | 95 |
| " " | Oleo vermelho | Brazil | × | | | × | | | × | | | 0.28 | 90 |
| " FRONDOSUS Allem. | Incienso | Argentina | × | | | × | | | × | | | 0.21–0.23 | 110–118 |
| " " | " | " | × | | | × | | | × | | | 0.19 | 128 |
| " " ? | Cabriuva | Brazil | × | | | × | | | | × | | 0.18–0.19 | 132–136 |
| MYROSPERMUM FRUTESCENS Jacq. | Cereipo | Venezuela | × | | | × | | | × | | | 0.25 | 100–102 |
| " sp. | " | " | × | | | × | | | × | | | 0.26–0.28 | 90– 95 |
| MYROXYLON TOLUIFERUM H.B.K. (*Toluifera balsamum* L.) | Balsamo de Tolu | Colombia | × | | | × | | | × | | | 0.23 | 109 |
| MYROXYLON TOLUIFERUM ? | Balsamo cope | " | × | | | × | | | × | | | 0.25 | 102 |
| OLNEYA TESOTA Gray | Ironwood | Southwestern United States | | × | | | × | | | | × | 0.16–0.17 | 150–160 |
| ORMOSIA CALAVENSIS Azaola | | Philippine Islands | × | | | | | × | × | | | 0.36 | 70 |
| " ROBUSTA Baker | | India | × | | | | × | | × | | | 0.37 | 68– 70 |
| OUGEINIA DALBERGIOIDES Benth. | Sandan | " | × | | | | × | | | × | | 0.16 | 154–160 |
| " " | " | " | × | | | × | | | | × | | 0.20 | 125 |
| PARKIA BIGLANDULOSA Wight & Arn. (Höhnel, 1, p. 38) | | Malaya? | × | | | × | | | | | | 0.20 | |
| PLATYMISCIUM DUBIUM Pittier | | Panama | × | | | | | × | × | | | 0.23–0.25 | 102–108 |
| " sp. (No. 428) | Trebo | Colombia | × | | | | × | | × | | | 0.27–0.28 | 88– 94 |
| " sp. (No. 404) | " | " | × | | | × | | | × | | | 0.25 | 98–100 |
| PLATYPODIUM MAXONIANUM Pittier | | Panama | × | | | × | | | × | | | 0.22–0.24 | 105–115 |
| PONGAMIA GLABRA Vent. (Solereder, 6, p. 903) | | Tropical Asia | | | | | | | | | | | |
| PONGAMIA MITIS Merr. | | Philippine Islands | × | | | × | | | | × | | 0.16 | 155–160 |
| PTEROCARPUS ANGOLENSIS DC. (Höhnel, 1, p. 34) | Barwood | | × | | | × | | | | | | 0.25? | |
| PTEROCARPUS DALBERGIOIDES Roxb. | Andaman Padouk | India | × | | | × | | | | × | | 0.22–0.23 | 112–117 |
| " DRACO L. | Pao sangue | Brazil | × | | | | × | | | × | | 0.20–0.21 | 120–125 |
| " ECHINATUS Pers. | Prickly Narra | Philippine Islands | × | | | | × | | | × | | 0.21 | 120 |
| " ERINACEUS Lam. (Höhnel, 1, p. 34) | | Senegal | × | | | × | | | | × | | 0.20? | |
| PTEROCARPUS INDICUS Willd. | Red Narra | Philippine Islands | × | | | × | | | | | | 0.20–0.21 | 120–125 |
| " MACROCARPUS Kurz | Padouk | India | × | | | × | | | | × | | 0.23–0.24 | 106–110 |
| " MARSUPIUM Roxb. | Vengai | " | × | | | × | | | × | | | 0.21–0.22 | 115–120 |
| " " | Bija Sal | " | × | | | × | | | | × | | 0.23 | 110 |

TABLE OF WOODS WITH TIER-LIKE STRUCTURE, SHOWING THE ELEMENTS STORIED, THE REGULARITY AND VISIBILITY OF THE TRANSVERSE LINES ("RIPPLE MARKS"), AND MEASUREMENTS OF TIER-HEIGHT—*Continued*

| Scientific name | Common name | Country | Elements storied | | | | Regularity of lines | | | | Visibility | | | | Measurements | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | All elements | Rays not storied | Wood parenchyma cells storied | Filer pits storied | Regular | Fairly regular | Irregular | Local occurrence | Distinct—fairly so | Barely visible | Lens required | Indistinct with lens | Tier-height in mm. | Number of tiers per inch |
| LEGUMINOSAE—*Continued* | | | | | | | | | | | | | | | | |
| PTEROCARPUS ROHRII Vahl? | | Brazil | × | | | | | × | | | | × | | | 0.26 | 95 |
| " SANTALINUS L. | Red Sanders | India | × | | | | × | | | | | × | | | 0.22 | 113 |
| PTEROGYNE NITENS Tul. (four specimens) | Ibiraro or Viraro | Argentina | × | | | | × | | | | | × | | | 0.25–0.28 | 90–100 |
| " sp.? | Cereipo | Venezuela | × | | | | × | | | | | × | | | 0.26 | 94 |
| SOPHORA CHRYSOPHYLLA Seem. | Mamani | Hawaii | | × | | | | × | | | | | × | | 0.16 | 155–160 |
| " SECUNDIFLORA Lag. | Frijolita | Southwestern United States | | × | | | | × | | | | | × | × | 0.16 | 160 |
| SWARTZIA GAILLARDI Pittier | | Panama | × | | | | | × | | | | × | | | 0.22–0.23 | 110–115 |
| " PANAMENSIS Benth. | | " | × | | | | × | | | | × | | | | 0.25 | 100–102 |
| " TOMENTOSA DC. (Stone and Freeman, 9, p. 55) | Wamara | British Guiana | × | | | | | ? | | | | × | | | | |
| TAMARINDUS INDICA L. | Tamarind | Hawaii | × | | | | | | × | | | × | | | 0.31 | 80 |
| TIPUANA SPECIOSA Benth. | Tipa | Argentina | × | | | | × | | | | × | | | | 0.20–0.21 | 120–125 |
| " sp. (No. 897) | " | " | × | | | | × | | | | × | | | | 0.18–0.19 | 130–135 |
| WALLACEODENDRON CELEBICUM Koord. | Banuyo | Philippine Islands | × | | | | | | × | | × | | | | 0.33–0.36 | 70– 75 |
| LYTHRACEAE (see page 260) | | | | | | | | | | | | | | | | |
| PHYSOCALYMMA SCABERRIMUM Pohl? | Brazilian Tulip | Brazil | × | | | × | × | | | | | | × | | 0.16 | 160 |
| MALVACEAE | | | | | | | | | | | | | | | | |
| GOSSYPIUM ARBOREUM L. | Cotton | Costa Rica | | × | | | | | × | | | × | | | 0.29 | 85 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GOSSYPIUM DRYNARIOIDES Seem. | Kokio | Hawaii | | × | × | | | | × | | | — | × | | |
| HIBISCUS GREWIAEFOLIUS Hassk. | | Philippine Islands | × | | | | × | | | × | | | | 0.33–0.36 | 70– 75 |
| " MACROPHYLLUS Roxb. | | Java | | × | | | | | × | | | | | | |
| " SIMILIS Blume (M.&J., 7, I, p. 375) | | " | | × | | | | | × | | | | | | |
| HIBISCUS TILIACEUS L. | Malubago | Philippine Islands | × | — | | | × | — | | × | | | | 0.28–0.30 | 85– 90 |
| SIDA DENSIFLORA Hook. & Arn. | Loro blanco | | | × | | | | × | | × | | | | 0.23 | 110 |
| THESPESIA POPULNEA Corr. (M.&J., 7, I, p. 389) | | India | × | — | | | | × | | × | | | × | 0.25 | 100 |
| MELIACEAE | | | | | | | | | | | | | | | |
| CARAPA GUIANENSIS Aubl.? | Andiroba | South America | × | | | | | | × | | × | | | 0.50 | 50 |
| " OBOVATA Blume (M.&J., 7, II, p. 200) | | Java | × | | | | | × | | | | × | | | |
| CEDRELA sp. (four specimens) | Cedro | Tropical America | × | | | | | | × | × | × | | × | 0.45–0.50 | 50– 55 |
| CHICKRASSIA TABULARIS A. Juss. (*Chukrasia tabularis* A. Juss.) | Chittagong Wood | India | × | | | | | | × | × | × | | | 0.31–0.32 | 78– 82 |
| ENTANDROPHRAGMA CANDOLLEI Harms | Sapeli | Africa | × | | | | | | × | × | × | | × | 0.5 | 50 |
| GUAREA TRICHILOIDES L. (Höhnel, 1, p. 39) | | | × | | | | × | | | | | | | | |
| KHAYA sp. | African Mahogany | Africa | × | | | | | | × | × | × | | × | 0.50 | 50 |
| SWIETENIA MAHAGONI Jacq. | Mahogany, Caoba | Tropical America | × | | | | | × | — | — | × | | | 0.46–0.54 | 46– 54 |
| MORACEAE | | | | | | | | | | | | | | | |
| FICUS ALTISSIMA Blume | | India | × | | | | | × | | | × | | × | 0.38–0.40 | 62– 66 |
| " BENJAMINA L. | Balete | Philippine Islands | × | | | | | × | | | × | | × | 0.39 | 64 |
| MORINGACEAE | | | | | | | | | | | | | | | |
| MORINGIA PTERYGOSPERMA Gärtn. (Höhnel, 1, p. 35) | Griesholz | | × | — | | | | | × | × | × | | | | |
| MORINGIA sp. (M.&J., 7, II, p. 514) | | Java | × | | | | | × | | | × | | | | |
| ROSACEAE (see page 260) | | | | | | | | | | | | | | | |
| FEROLIA GUYANENSIS Aubl.? (*Parinarium* sp.; Höhnel, 1, p. 43) | Ficatin- or Königsholz | Guiana | × | | | | × | | | | | | | | |

TABLE OF WOODS WITH TIER-LIKE STRUCTURE, SHOWING THE ELEMENTS STORIED, THE REGULARITY AND VISIBILITY OF THE TRANSVERSE LINES ("RIPPLE MARKS"), AND MEASUREMENTS OF TIER-HEIGHT—*Continued*

| Scientific name | Common name | Country | Elements storied | | | | Regularity of lines | | | | Visibility | | | | Measurements | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | All elements | Rays not storied | Wood parenchyma cells storied | Fiber pits storied | Regular | Fairly regular | Irregular | Local occurrence | Distinct—fairly so | Barely visible | Lens required | Indistinct with lens | Tier-height in mm. | Number of tiers per inch |
| **RUTACEAE** | | | | | | | | | | | | | | | | |
| CHLOROXYLON SWIETENIA DC. | Satinwood | India | × | | | | | × | | | × | | | | 0.31–0.32 | 78– 82 |
| **SAPINDACEAE** | | | | | | | | | | | | | | | | |
| SAPINDUS SENEGALENSIS Poir. (Höhnel, 1, 43) | | Africa? | | × | | × | × | | | | | | × | | 0.20 | |
| **SIMARUBACEAE** | | | | | | | | | | | | | | | | |
| PICRAENA EXCELSA Lindl. (Höhnel, 1, p. 41; Wiesner, 5, p. 955) | Jamaica Quassia | West Indies | — | × | | | ? | | | | | | × | | | |
| PICRASMA JAVANICA Blume (M.&J., 7, II, 84) | | Java | × | | | | × | | | | × | | | | 0.30 | |
| SIMARUBA AMARA Aubl. | Pao parahyba | Brazil | × | | | | | × | | | × | | | | 0.43 | 58– 60 |
| " GLAUCA DC. | Bitterwood | Florida | × | | | | | × | — | | × | | | | 0.50 | 51– 52 |
| SURIANA MARITIMA L.? | Palo corra | Curaçao | × | | | | | × | | | | × | | | 0.21 | 120 |
| **STERCULIACEAE** | | | | | | | | | | | | | | | | |
| GUAZUMA ULMIFOLIA Lam. | Guasima | Curaçao | | × | | | | | × | | | × | | | 0.30–0.31 | 80– 85 |
| HERITIERA LITTORALIS Ait. | Dungon late | Philippine Islands | | × | | | | — | × | | | × | | | 0.31 | 80 |
| " MINOR Lam. | Sundri | India | | × | | | | — | × | | | × | | | 0.31–0.32 | 77– 80 |
| " " | " | " | | × | | | | × | | | | × | | | 0.27 | 92 |
| KLEINHOVIA HOSPITA L. | | " | × | — | | | | × | | | | × | | | 0.31–0.33 | 74– 80 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MELOCHIA INDICA Gray (M.&J., 7, I, p. 469) | | Java | × | — | | | × | | | × | | | | | |
| PTEROCYMBIUM JAVANICUM R.Br. (M.& J., 7, I, p. 440) | | " | | × | | | × | | | | × | | | 0.40 | |
| PTEROCYMBIUM TINCTORIUM Merr. | | Philippine Islands | | × | × | × | × | | | × | | | | 0.45–0.50 | 50– 55 |
| PTEROSPERMUM DIVERSIFOLIUM Blume | | Java | | × | | | × | — | | × | — | | | 0.50 | |
| " JAVANICUM Jungh. (M.& J., 7, I, p. 463) | | " | | | | | | | | | | | | | |
| | | " | | × | | | × | — | | × | — | | | 0.50 | |
| PTEROSPERMUM SUBERIFOLIUM Lam. (Höhnel, 1, p. 42) | | India | × | — | | | × | | | × | | | × | 0.30–0.31 (0.25,H.) | 80– 85 |
| PTEROSPERMUM sp. | Bayok | Philippine Islands | × | | | | × | | | × | | | | 0.38 | 66 |
| STERCULIA FOETIDA L. (M.&J., 7, p. 424) | | Java | | × | × | | | | | | | | | | |
| " POPULIFOLIA Roxb. | Dalibuda | India | | × | × | | × | | | × | | | | 0.36 | 70 |
| TARRIETIA ARGYRODENDRON Benth. | Crow's-foot Elm | Australia | | × | | | × | | | × | | | | 0.36 | 70 |
| " JAVANICA Blume | Lumbayao | Philippine Islands | | × | | | × | | | × | | | | 0.36–0.41 | 60– 70 |
| " SUMATRANA Miq. (M.&J., 7, I, p. 446) | | Java | | × | | | × | | | × | | | | 0.30 | |
| TARRIETIA SYLVATICA (Vidal) Merr. | Dungon | Philippine Islands | | × | | | × | | | × | | | | 0.32–0.33 | 83– 85 |
| " " | " | " " | | × | | | × | | | | × | | | 0.26–0.28 | 90– 95 |
| TILIACEAE | | | | | | | | | | | | | | | |
| BERRIA AMMONILLA Roxb. | | Java | × | — | | | × | | | × | | | | 0.25 | |
| " QUINQUELOCULARIS T.&B. (M.& J., 7, I, pp. 492, 496) | | " | | × | | | | × | × | | | | | | |
| COLUMBIA SERRATIFOLIA DC. | Analin | Philippine Islands | — | × | | | × | | | × | | | | 0.31–0.33 | 75– 80 |
| DIPLODISCUS PANICULATUS Turcz. | Baloba | " " | × | | | | × | | | × | | | | 0.31–0.33 | 75– 80 |
| GREWIA CELTIDIFOLIA Juss. | | Java | | × | | | × | | | × | | | | | |
| " LAEVIGATA Vahl (M.&J., 7, I, pp. 499, 507) | | " | | × | | | × | | | × | | | | 0.23 | |
| GREWIA ROLFEI Merr. | Danglin | Philippine Islands | | × | | | × | | | | × | | | 0.24–0.25 | 100–105 |
| " TILIAEFOLIA Vahl | | India | | × | | | × | | | | × | | | 0.23 | 110 |
| HELIOCARPUS AMERICANUS L. | Amor seco | Argentina | | × | | | × | | | | × | | | 0.33 | 75 |
| " APPENDICULATUS Turcz. | | Panama | | × | × | | | × | | × | | | | 0.38 | 65 |
| PENTACE POLYANTHA Hassk. (M.&J., 7, p. 488) | | Java | × | | | | × | | | × | | | | 0.40 | |
| SCHOUTENIA OVATA Korth. (M.&J., 7, I, p. 522) | | " | — | × | | | × | — | | × | — | | | 0.22 | |

TABLE OF WOODS WITH TIER-LIKE STRUCTURE, SHOWING THE ELEMENTS STORIED, THE REGULARITY AND VISIBILITY OF THE TRANSVERSE LINES ("RIPPLE MARKS"), AND MEASUREMENTS OF TIER-HEIGHT—*Continued*

| Scientific name | Common name | Country | Elements storied | | | | Regularity of lines | | | | Visibility | | | | Measurements | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | All elements | Rays not storied | Wood parenchyma cells storied | Fiber pits storied | Regular | Fairly regular | Irregular | Local occurrence | Distinct—fairly so | Barely visible | Lens required | Indistinct with lens | Tier-height in mm. | Number of tiers per inch |
| **TILIACEAE—*Continued*** | | | | | | | | | | | | | | | | |
| TILIA AMERICANA L. | Basswood | Eastern United States | | × | | | | × | — | | | × | | × | 0.42–0.45 | 55– 60 |
| " CORDATA Mill. var. JAPONICA | | Japan | | × | | | | × | | | — | × | | × | 0.48 | 52 |
| " HETEROPHYLLA Vent. | Basswood | Southeastern United States | | × | | | | × | — | | | × | | × | 0.40–0.41 | 60– 62 |
| " MANDSHURICA Rupr. | | China | | × | | | | × | | | | × | | × | 0.45 | 56 |
| " PUBESCENS Ait. (Record, **8**, p. 76) | Basswood | Eastern United States | | × | | | | × | — | | | × | | × | 0.41–0.43 | 58– 60 |
| **ULMACEAE** | | | | | | | | | | | | | | | | |
| HOLOPTELEA INTEGRIFOLIA (Roxb.) Planch. (*Ulmus integrifolia* Roxb.) | | India | × | | | | | × | | | | | × | | 0.22–0.23 | 110–115 |
| **ZYGOPHYLLACEAE** | | | | | | | | | | | | | | | | |
| BULNESIA ARBOREA (Jacq.) Engl. | Vera | Venezuela | × | | | | × | | | | | | × | | 0.10 | 250 ± |
| " SARMIENTI Lorentz | Palo santo | Argentina | × | | | | × | | | | | | × | | 0.10 | 240–250 |
| GUAIACUM COULTERI Gray | Guayacan | West Coast Mexico | × | | | | × | | | | | | × | | 0.09 | 260–270 |
| " OFFICINALE L. | Lignumvitae | West Indies | × | | | | × | | | | | | × | | 0.10 | 250–260 |
| " SANCTUM L. | " | Florida | × | | | | × | | | | | | × | | 0.09 | 260–270 |
| LARREA CUNEIFOLIA Cav. (Solereder, **6**, p. 182) | | Argentina? | | | | | | | | | | | | | | |
| LARREA DIVARICATA Cav. | Javilla | " | × | | | | × | — | | | | | × | | 0.09 | 270–280 |
| PORLIERA HYGROMETRA Ruiz & Pav. (*Guaiacum hygrometricum* Bail.; Höhnel, **1**, p. 40) | Guayac | Chile | × | | | | × | | | | | | × | | 0.09–0.10 | |

SUMMARY

Storied or tier-like arrangement of part or all of the elements is characteristic of many dicotyledonous woods representing a wide range of natural orders and families. The storied structure is found also in the secondary phloëm.

The structure is exhibited on longitudinal sections, typically the tangential, as fine transverse striations ("ripple marks"). These are often visible without a lens.

"Ripple marks" are constant enough in stems of considerable thickness to serve as a valuable diagnostic feature.

In some woods pit areas on the fibers are in seriation. In some instances, also, the cells of the wood parenchyma strands are arranged in a secondary seriation, visible under the lens.

A table is appended giving for each wood the various elements storied, the uniformity and distinctness of the markings, and the height of the tiers.

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# The ancestry of maize—a reply to criticism

PAUL WEATHERWAX

In a recent article by H. J. Kempton (1), of the Bureau of Plant Industry, exception is taken to some statements made by me in a paper appearing last September in the Bulletin of the Torrey Botanical Club (**45**: 309–342), on the evolution of maize. Inasmuch as some real errors are pointed out in this criticism, their correction is in order; but, as to certain other points upon which our data differ, I have nothing to add to my original paper. Our differences of opinion on matters of interpretation and evaluation of facts would probably not be diminished by further discussion; and any criticism on ethical grounds of the spirit of Kempton's paper and his imputations of the writer's ignorance are left to the fair judgment of the reader. But Kempton's manner of treating details and his intermingling of the irrelevant with the relevant have clouded the issue, and a brief presentation of its present status seems appropriate.

It is said (p. 4) that I have misrepresented Collins (2) by confusing bracts with prophylla and by substituting "one-rowed" for "single-rowed" in a quotation. Both points are well taken, for no misrepresentation was intended. These errors had been discovered long before the appearance of Kempton's paper, and steps had already been taken to correct them; this is a welcome opportunity to do so.

The error in speaking of the husk of the maize ear as prophylla (pp. 314, 330) does involve an unintentional misrepresentation of Collins's statement; but this point is beside the question, for the true prophylla of all kinds of maize, including pod corn, have buds in their axils, which is the significant point. Whether or not these buds develop far enough to be visible externally is a quantitative matter. The difference between "one" and "single" in the quotation (p. 321), describing the pistillate spike of teosinte, is appreciated, and it is unfortunate that the substitution was made. But the bearing of this point upon the evolution of

the ear is unchanged, for the fact remains that Collins (p. 525, footnote) was using the structure of the spike of teosinte in an attempt to explain the appearance of ears with odd numbers of rows in some hybrids between maize and teosinte; and a "single-rowed" spike, such as that of teosinte, is of no avail in getting around the difficulty, for it has *two* rows of functional spikelets, not to mention the aborted ones.

Kempton's support (pp. 6–7) of the theory that the ear of maize originated by fasciation is based chiefly upon certain true-breeding races having bifurcated ears and a bifurcated central spike in the tassel. But our only evidence of the regressive nature of these mutants is the fasciation theory itself, and reasoning of this kind does not make much progress. The fact that ears having rows not in multiples of four could not have been formed by the union of spikes having four rows each is evaded by Kempton's assumption (p. 7) that a row of pairs of spikelets or the pedicelled spikelets of two such rows were aborted. Abortion of parts is a common occurrence in maize, but our best evidence of this is in finding their rudiments; and, if abortion is thought to be responsible for the occurrence of ears with ten, fourteen, or eighteen rows, the burden of proof is with those who reject a more simple and more direct explanation of the situation. Such an explanation is afforded by the theory that the ear and the central spike of the tassel have developed from a branched inflorescence like that of some of the sorghums. The assumption here involved is that the pairs of spikelets are the remnants of reduced branches; and material illustrative of intermediate steps in this reduction is afforded by branch corn, which was unknown when Collins (p. 526) rejected this theory.

Advocates of the hypothesis that maize arose by hybridization find the necessity for their position in the fact that ordinary maize has so many primitive characteristics and seems to occupy an intermediate position between teosinte, which is more highly specialized, and pod corn, which seems to be more primitive than ordinary maize.

A detailed morphological study shows that the differences in specialization here concerned are neither so great nor so significant as was supposed when the hypothesis was first advanced; but further discussion of this point is waived for the present.

The primitive characters of the maize plant might cause some difficulty in connection with any theory to the effect that maize descended from teosinte itself or from some plant much like teosinte; but probably no one at present gives serious consideration to any such theory. In descending directly from a primitive ancestor, the plant need not have made equal progress in all respects, and a combination of highly specialized characters with others relatively simple would be expected. Probably no one appreciates more fully than does the systematist the significance of this principle.

The weakest spot in the hypothesis of the hybrid origin of *Zea* lies in the fact that pod corn has not been shown to be essentially different from ordinary corn except in the possession of enlarged bracts and of functional pistils in the tassel. In Collins's argument, pod corn has no exact identity. Sometimes it has ears, and sometimes it is earless. He seems to have selected from all the characteristics possessed by this ill-defined variety those tending to uphold his hypothesis. Kempton admits as much (p. 7) when he attributes the presence of buds in the axils of the leaves of pod corn to the recent origin of this variety from ordinary corn. The problem for which they offer no solution involves a means of distinguishing the characters of the orthodox podded type—one of the hypothetical ancestors of *Zea*, according to their view—from other characters received from ordinary maize by this recent mutant. It is true that the hybrid-origin hypothesis itself will distinguish them, but, when we apply it, we find ourselves dealing in circular logic. It is generally admitted that the podded types now in existence are recent mutations rather than original forms; but our criterion for the regressive nature of some of their characteristics is in the character of the grasses held to be closely related to maize.

The idea of the hybrid origin of maize has had the misfortune to be based upon a hypothesis not substantiated by subsequently discovered facts. It has never been very enthusaistically accepted by botanists in general, because it seems unreasonable and taxes the imagination unnecessarily. It has had its good effect in promoting further investigation, but it has run its course and has been found wanting.

On the other hand, comparative morphology, which has been one of the most reliable and productive agents in establishing lasting theories of evolution, points out clear-cut, logical, reasonable evidence of the direct origin of *Zea*, coördinately with *Euchlaena* and *Tripsacum*, from an ancestor long ago extinct. There has been pointed out no accepted fact whose rational interpretation discloses any inconsistency in the theory. The three genera are different simply because they have lost different organs that were possessed by their progenitor and have specialized others to different degrees.

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# INDEX TO AMERICAN BOTANICAL LITERATURE

## 1911–1919

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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